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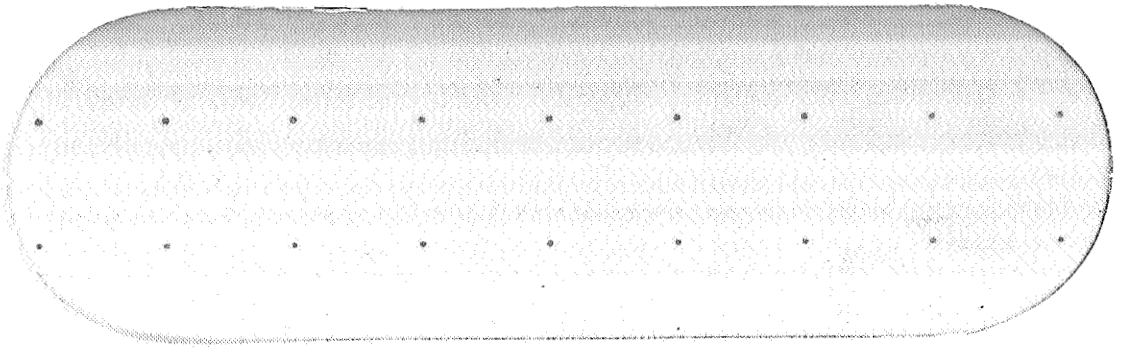

SPACE DIVISION LAUNCH SYSTEMS BRANCH

THE BOEING COMPANY
AERO-SPACE DIVISION
SATURN BOOSTER BRANCH

DOCUMENT NO. T5-6539-104

VOLUME _____ OF _____

TITLE Failure Analysis of Actuator Boot Fittings

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ABSTRACT

Servoactuator boot fittings, P/N 60B21146 -1 and -2, failed by cracking on the S-IC-502 vehicle at KSC. Subsequent analysis revealed that the parts had not been shimmed on assembly and resultant high installation stresses induced stress corrosion cracking in the saline atmosphere at the Space Center. It also developed that an E.O. against the assembly drawing required shimming an all vehicles except the 502. This suggests that this type of failure would be peculiar to this stage. New units, same part numbers as above, were procured and installed with proper shimming to eliminate installation stresses and also reduce the possibility of stress corrosion.

KEY WORDS

Boot Fittings

Cracking

Servoactuator

S-IC-502

Stress Corrosion

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List of Figures

1.0 Object. - This investigation was conducted to determine the cause of failures in servoactuator boot fittings on the S-IC-502 stage.

2.0 Background. - U.E.R. Numbers 285401 and 285402 reported cracked servoactuator boot fittings on the S-IC-502 vehicle at KSC and required replacement with new fittings and proper fit-up provided by shims. AAR 5-7350-M-490 required further analysis of the failures and one each of part numbers 60B21146-1 and -2 were sent to the Boeing M&P Laboratory in New Orleans and another pair was shipped to R-P & VE-M in Huntsville for this purpose.

The parts were made from forged blocks in accordance with drawing number 60B21146, figure 1 of this report.

Installation of the fittings is made in accordance with the requirements of drawing number 60B21145. E.O.1 to this drawing required shimming of misalignment on all vehicles except 502 which was omitted for some undetermined reason.

3.0 Conclusions. - High tensile installation stresses resulted from poor fit-up on assembly and were probably in excess of the stress corrosion threshold stress of 7079-T6 aluminum alloy. The combination of these sustained tensile loads and atmospheric exposure caused stress corrosion cracking of the boot fittings.

4.0 Recommendations. - The reduction of installation preloads will reduce the possibility of stress corrosion cracking. However, to negate all possibility of this type of cracking a more stress corrosion resistant alloy, such as 7075-T73, should be considered in the future.

5.0 Procedures and Results. - On receipt, the fittings were dye penetrant inspected. The results of this inspection are evident in figures 2 and 3 for -1 and -2 parts respectively. Arrows indicate the crack locations at the inner bolt holes and near the machined radii.

The grain direction required by drawing number 60B21146 was confirmed in each part by macroscopy and is illustrated in figure 4 as typical for each part.

Spectrographic analysis was used to confirm the alloy to be 7079 and, hardness and conductivity measurements determined the temper to be T-6.5.

5.0 Procedure and Results (Continued)

Figure 5 shows the fracture faces of one crack taken from the 60B21146-1 part and is again typical of all other cracks examined in both -1 and -2 parts. The faces exhibit an exfoliated appearance. Figure 6 is a micrograph of a cross section taken at one edge of this fracture. Note the branching nature of the crack. The lower photograph is an enlargement of the indicated zone in the top photograph. Figure 7 is a micrograph taken of a longitudinal section. Though the intergranular paths of the cracking found in this investigation were not as dramatic or classical as in other cases, sufficient evidence was provided to attribute the failures to stress corrosion cracking.

6.0 Reference

a. Test Progress Report, T5-6739 Vol. VII, Section 115
b. Quality Laboratory Test Report LSR0513
c. 60B21145
d. 60B21146

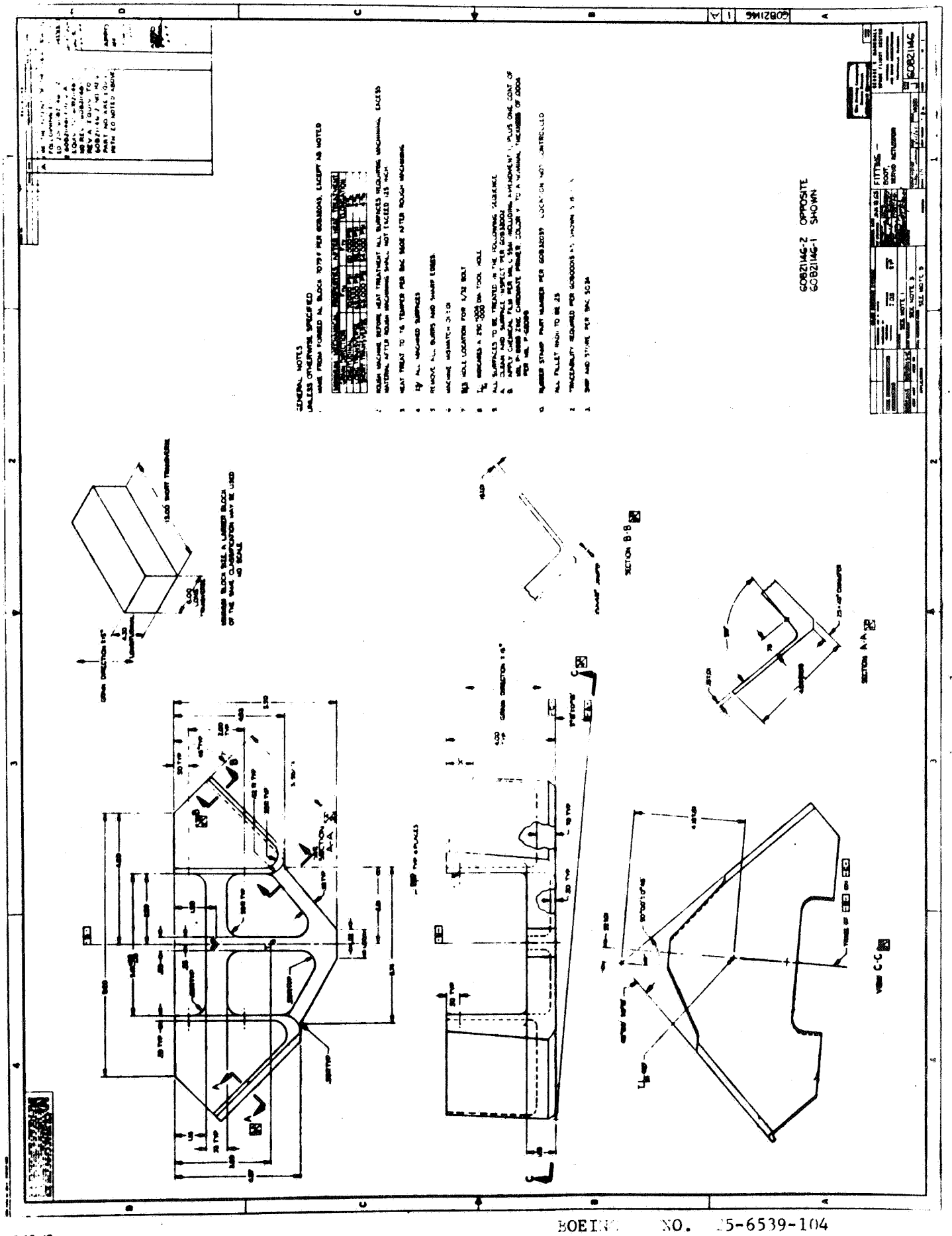


Figure 1

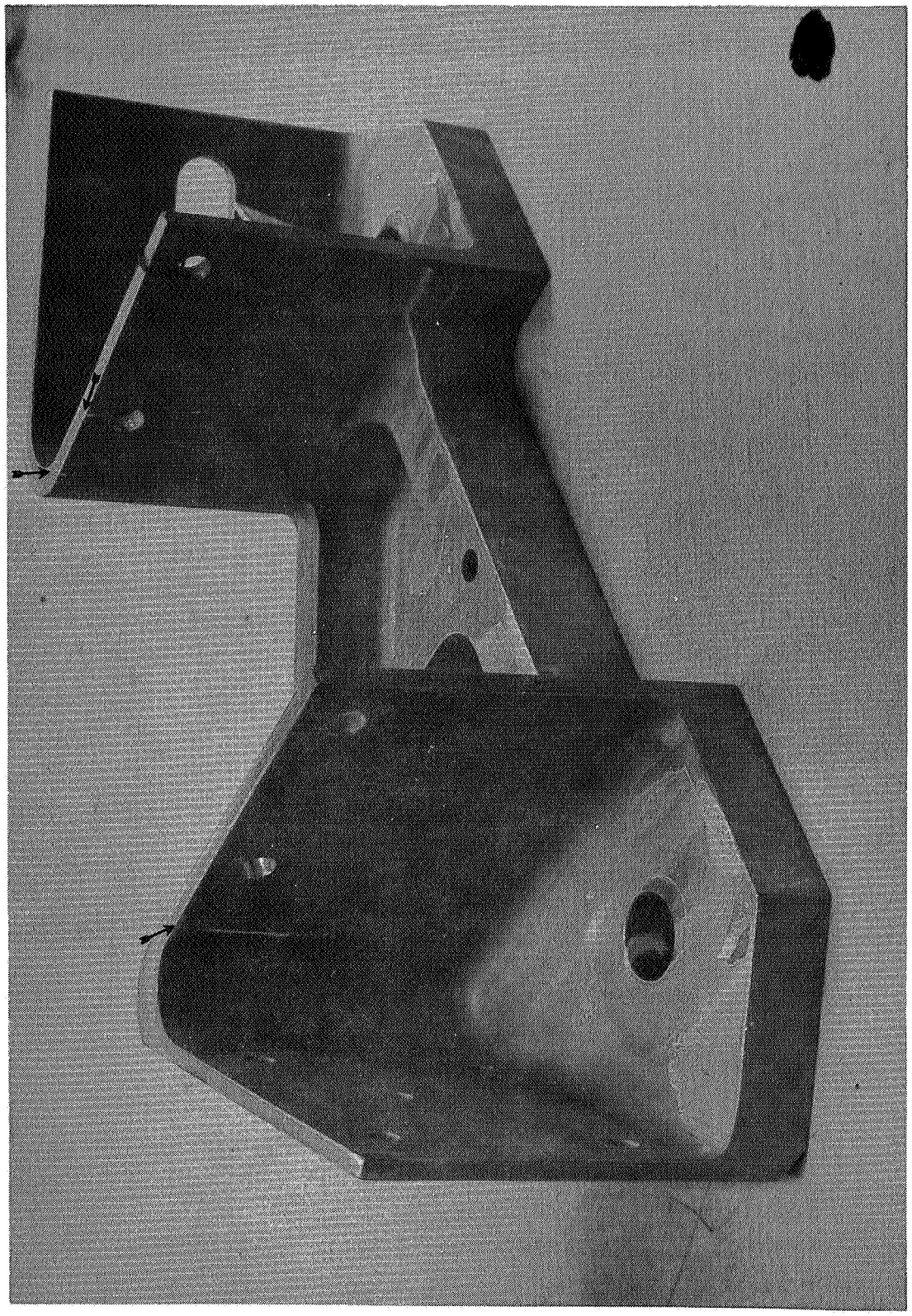


Figure 2 Part Number 60B21146-1 Crack Indications ~ 1/2 size

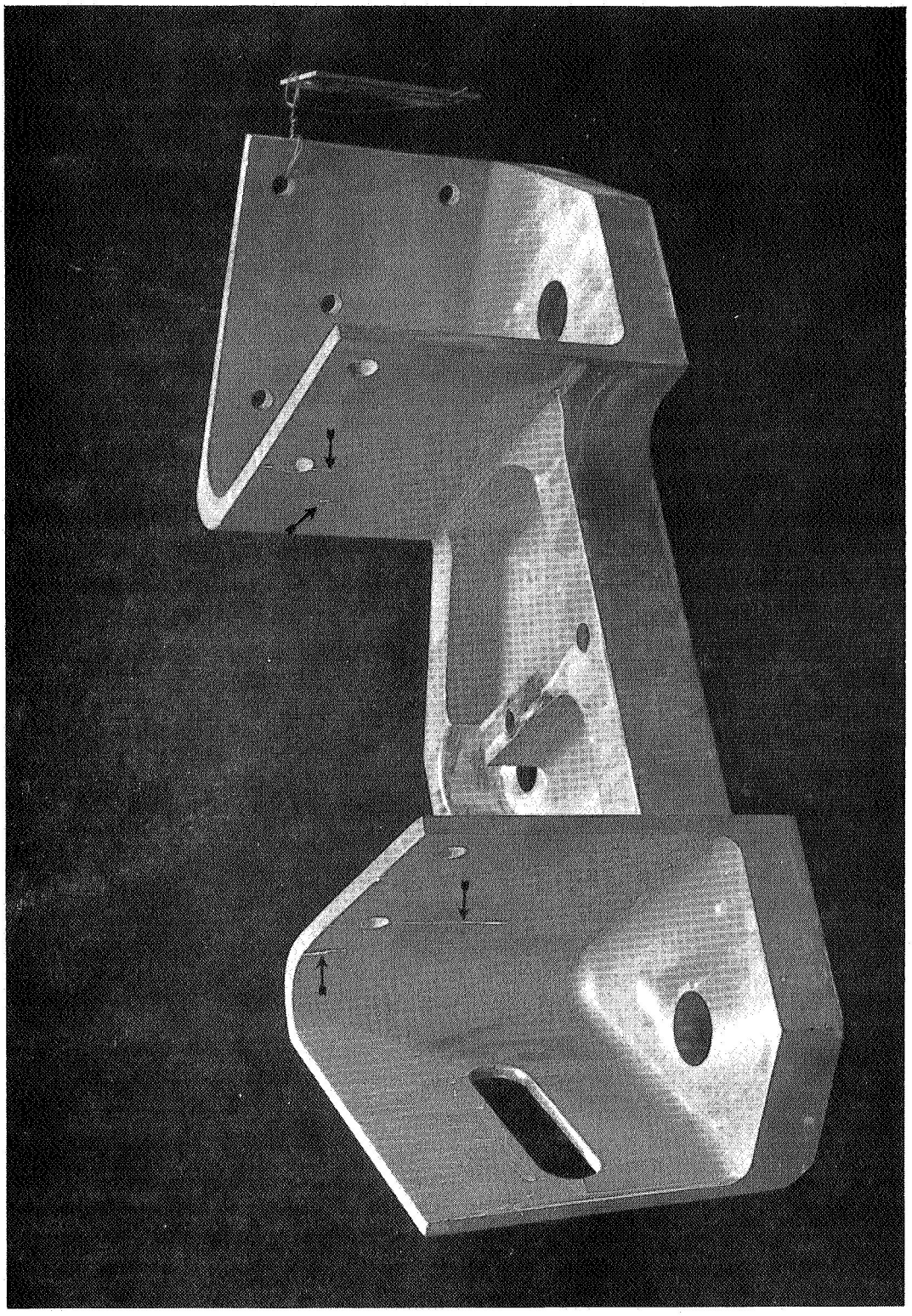
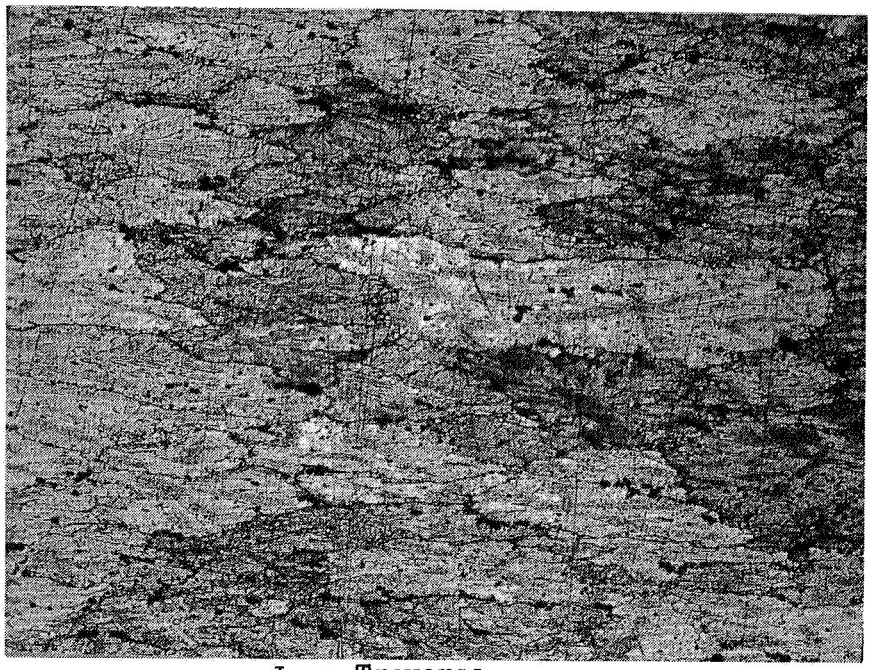
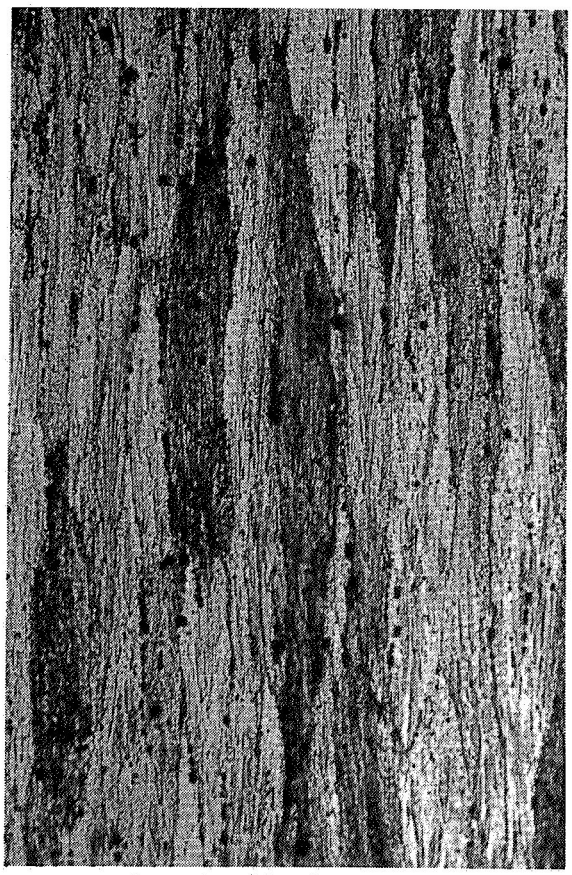


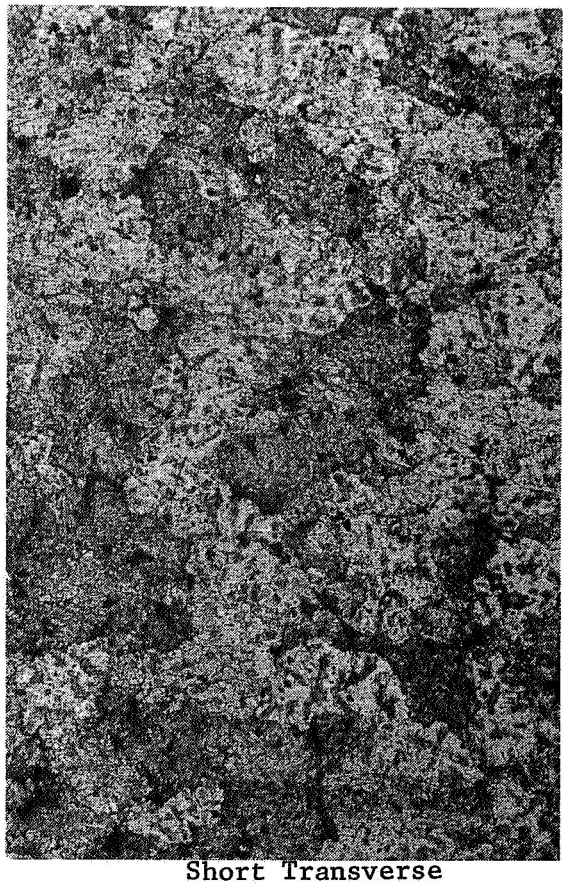
Figure 3 Part Number 60B21146-2 Crack Indications ~ 1/2 size



Long Traverse



Longitudinal
Keller's Etch



Short Transverse
50X

Figure 4 Forging Grain Directions

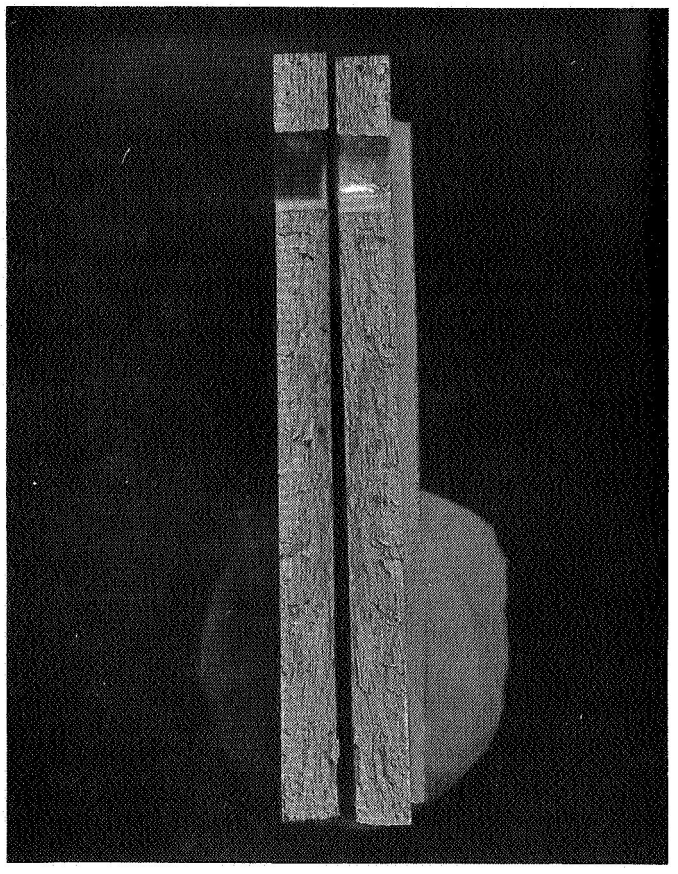
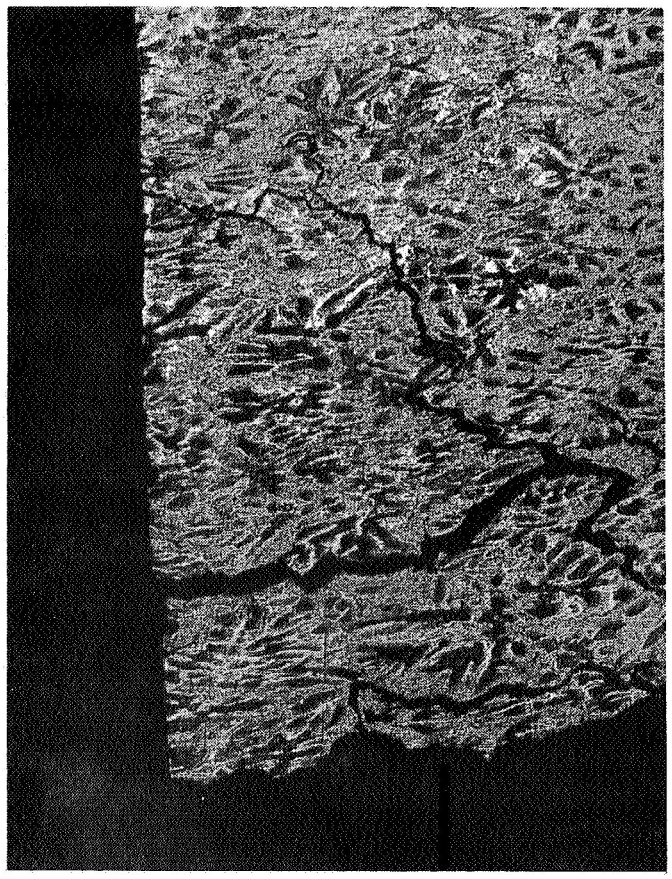
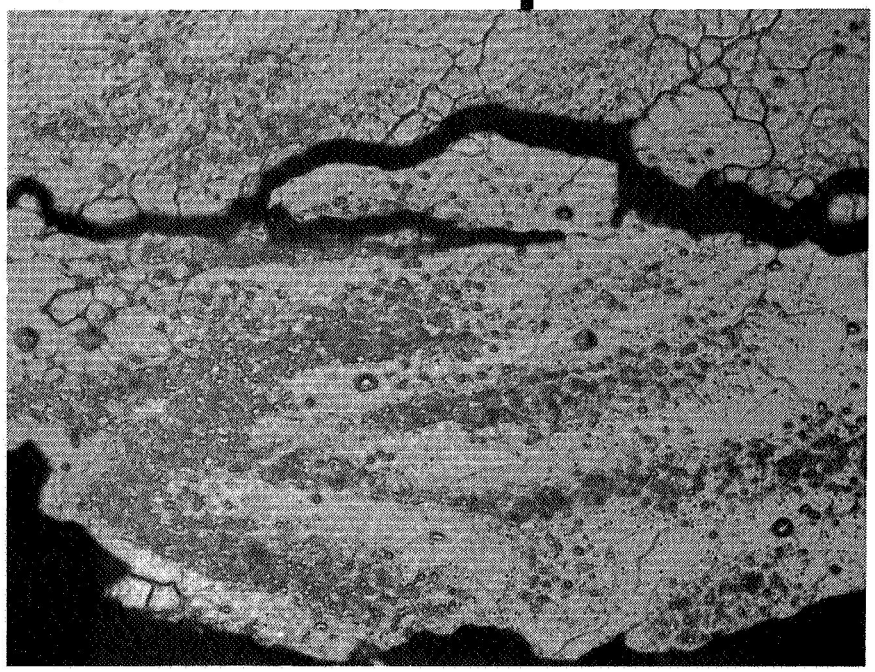


Figure 5 Fracture Faces of One Crack ≈ 1.5X



Keller's Etch 50X



500 X

Figure 6 Cross Section Through Fracture

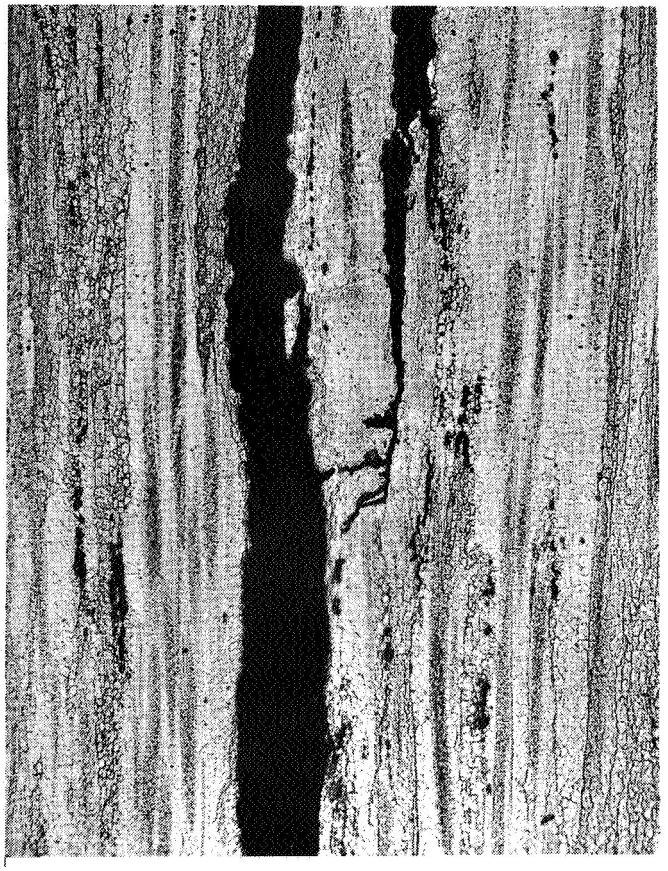


Figure 7 Longitudinal Section of Fracture